

Comparison Between Control-Based Continuation and Phase-Locked Loop Methods for the Identification of Backbone Curves and Nonlinear Frequency Responses

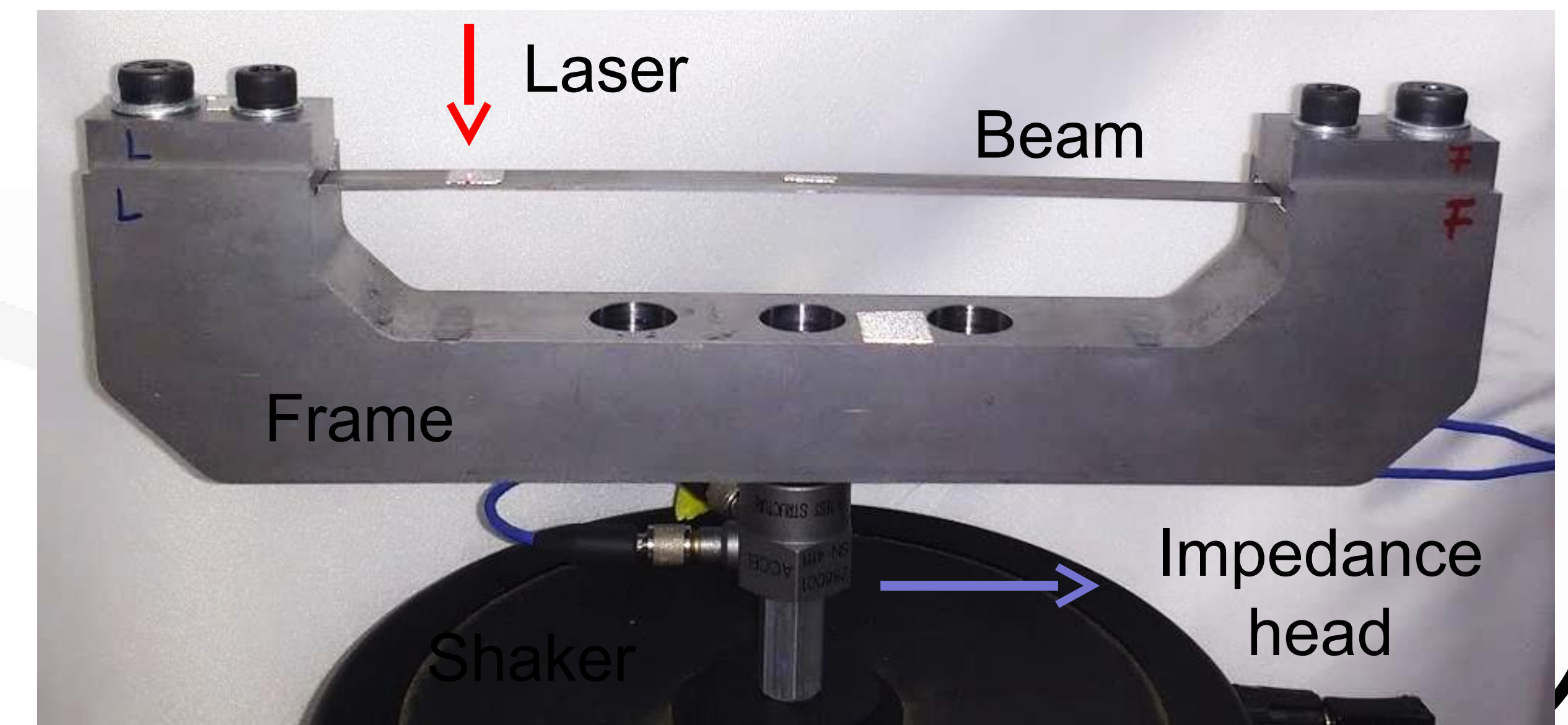
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Motivation

- Model-less experimental characterization of nonlinear structures with PLL and CBC
 - Backbone Curves
 - Nonlinear Frequency Responses
- No direct comparison of the methods has been performed until now

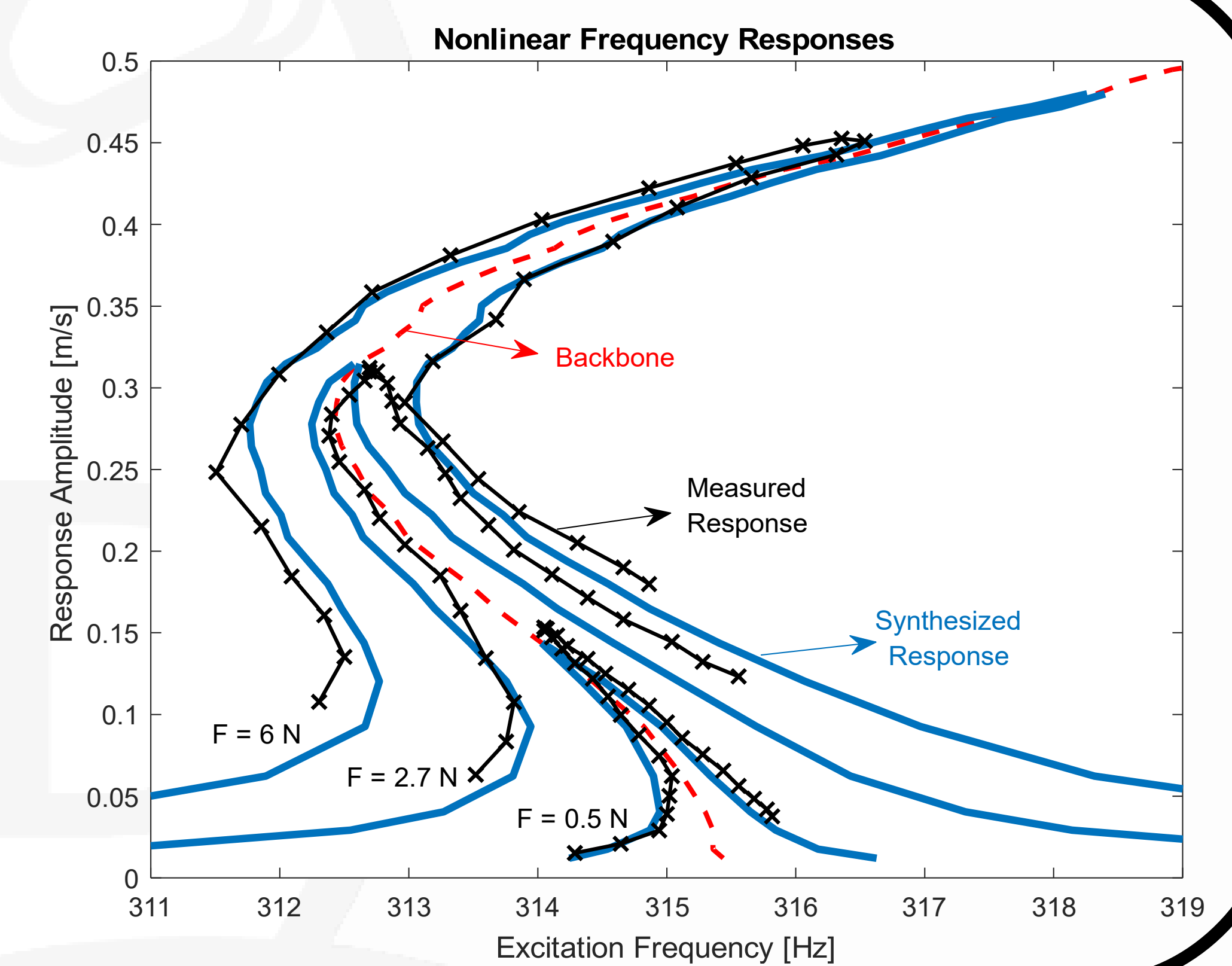
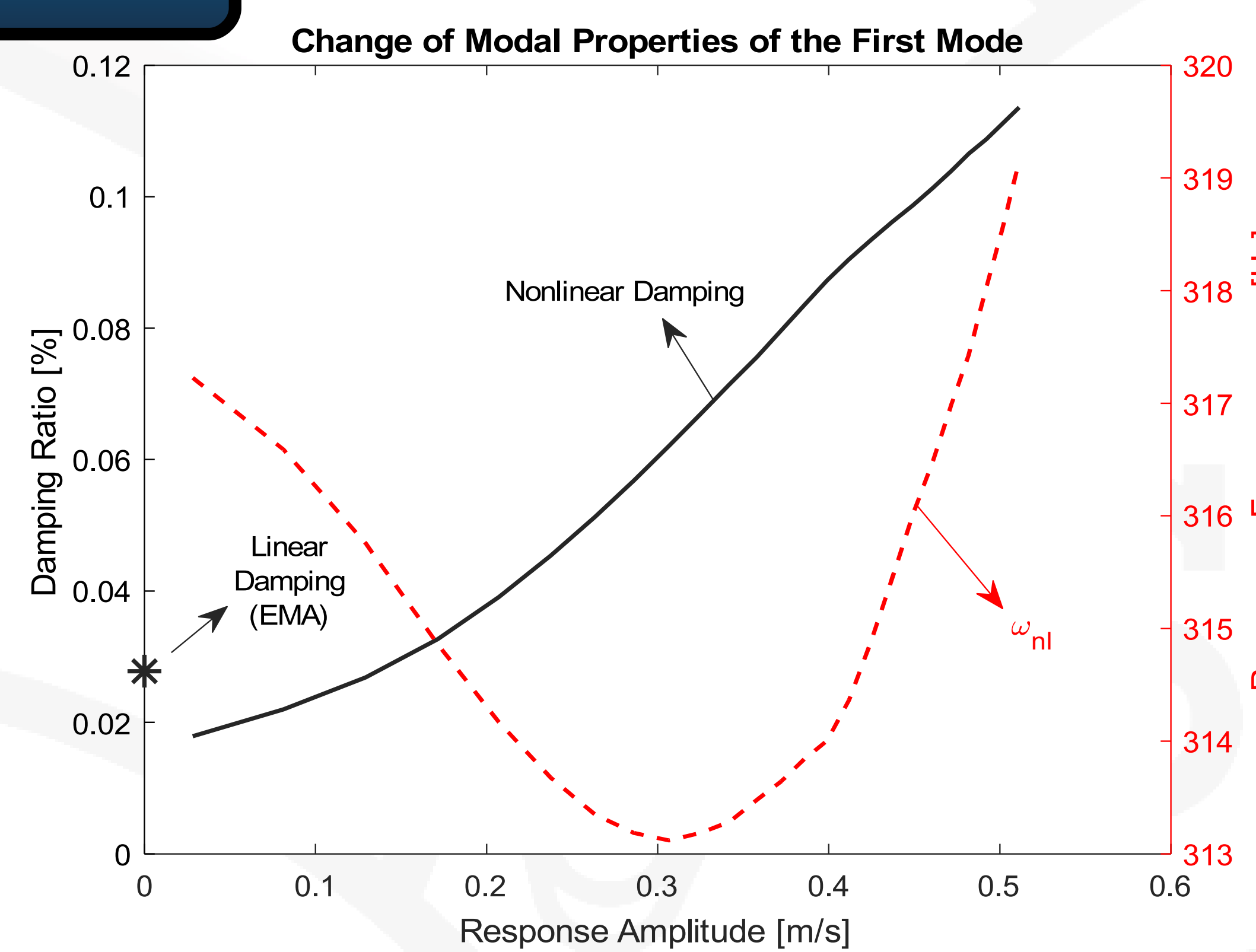
Experimental Setup

- Clamped-clamped curved beam
- Base excitation
- Velocity measured by laser
- Force measured by impedance head



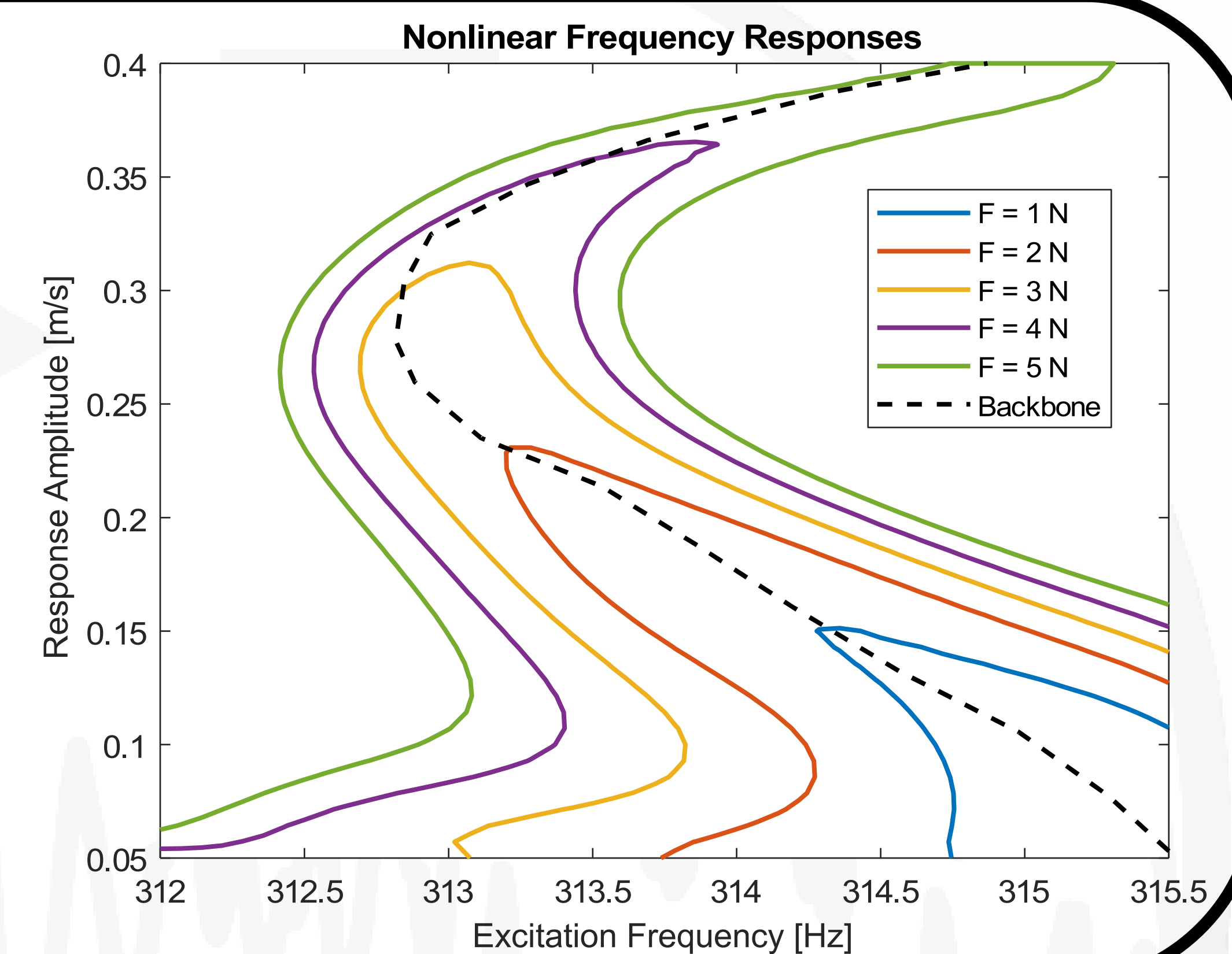
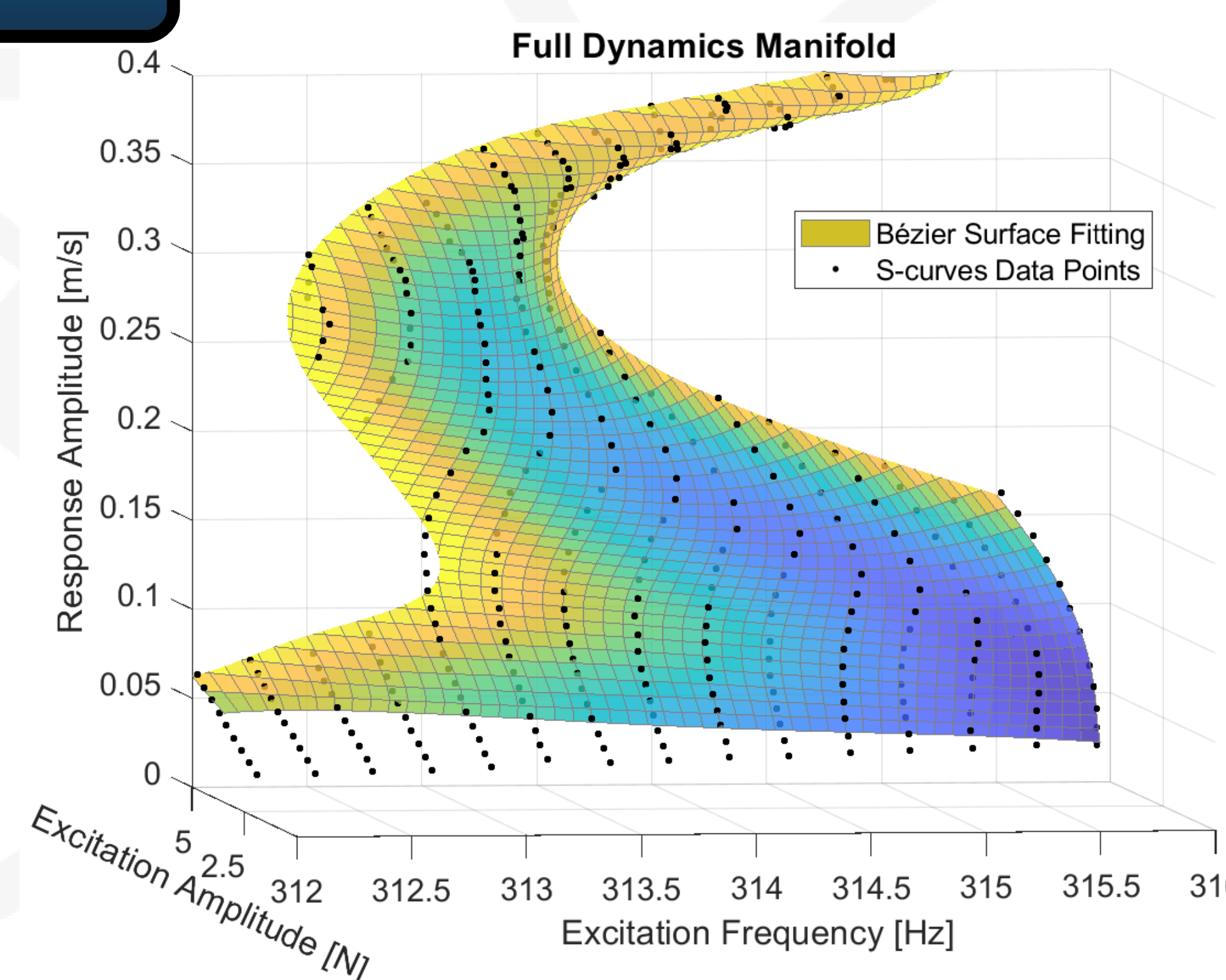
Phase-Locked Loop (PLL)

- Phaselag between excitation (=force) and response (=velocity) is evaluated online and controlled to a specific value
 - Stepping from low to high excitation amplitude at phaselag = 0° yields backbone curve
 - Stepping through phaselag at constant excitation amplitude yields frequency response including instable branches
- From the backbone measurement results:
 - amplitude dependent damping is calculated
 - frequency response is synthesized



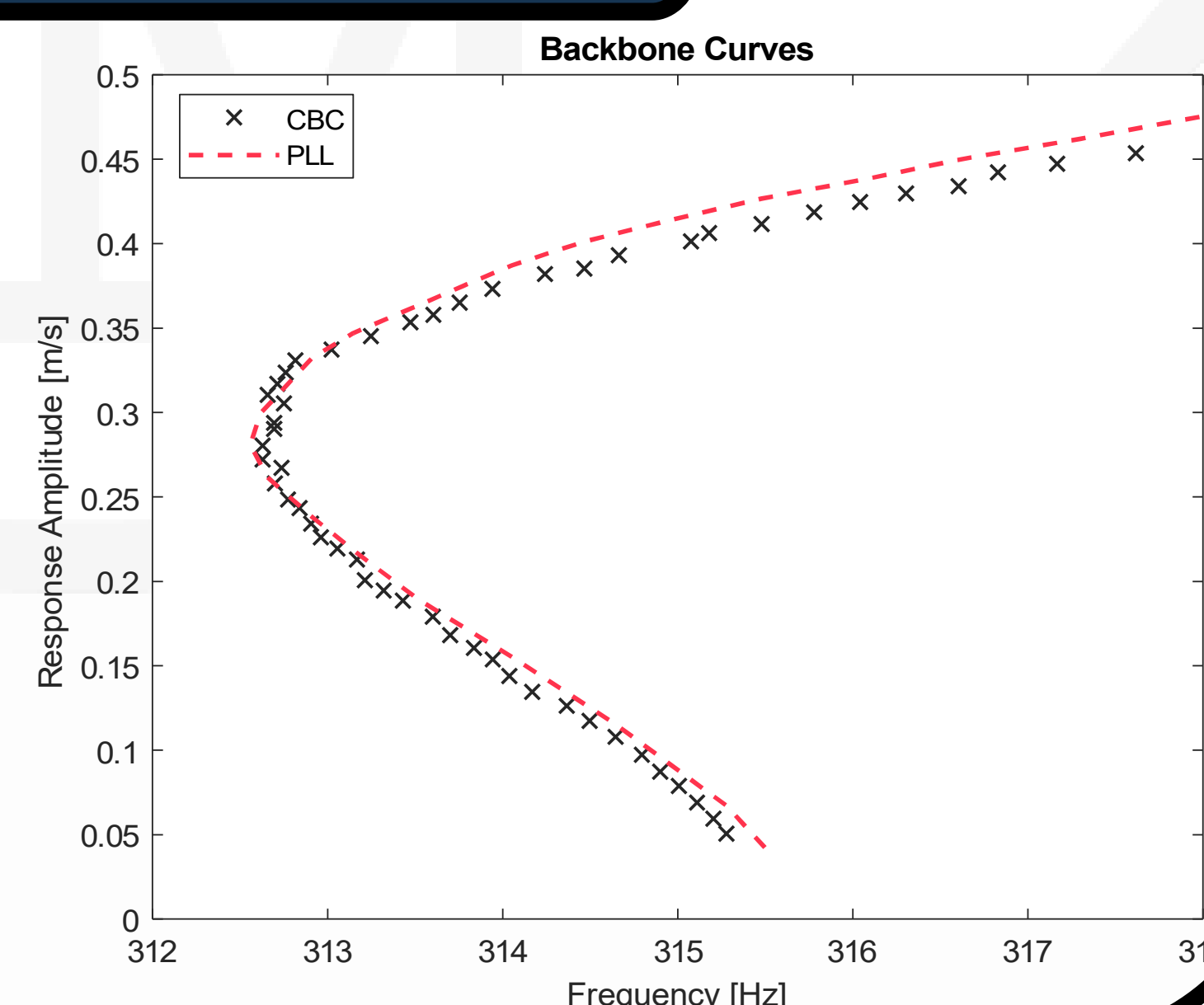
Control-Based Continuation (CBC)

- Response amplitude is imposed by a PD controller
 - Control is made non-invasive by Picard iterations
 - Measured excitation force is made mono-harmonic by Newton iterations
- Backbone curves are obtained by increasing the response amplitude and tuning the excitation frequency until the quadrature of phase
- S-curves are obtained by increasing the response amplitude at constant excitation frequency
- The full dynamics manifold is constructed by minimizing the distance between a Bézier surface and S-curves data points



Conclusions

- Backbones obtained by both methods are consistent
- Nonlinear frequency response curves can be obtained by both methods
- Higher forcing harmonics can be cancelled with both methods
- Further studies could focus on:
 - comparison of performance
 - more complex nonlinearities



References

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- [2] Peter, S., & Leine, R. I. (2017). Excitation power quantities in phase resonance testing of nonlinear systems with phase-locked-loop excitation. *Mechanical Systems and Signal Processing*, 96, 139-158.
- [3] Renson, L., Gonzalez-Buelga, A., Barton, D. A. W., & Neild, S. A. (2016). Robust identification of backbone curves using control-based continuation. *Journal of Sound and Vibration*, 367, 145-158.
- [4] Renson, L., Barton, D. A., & Neild, S. A. (2017). Experimental tracking of limit-point bifurcations and backbone curves using control-based continuation. *International Journal of Bifurcation and Chaos*, 27(01), 1730002.